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A detailed loads comparison of three building energy modeling programs: EnergyPlus, DeST and DOE-2.1E

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Abstract

Building energy simulation is widely used to help design energy efficient building envelopes and HVAC systems, develop and demonstrate compliance of building energy codes, and implement building energy rating programs. However, large discrepancies exist between simulation results from different building energy modeling programs (BEMPs). This leads many users and stakeholders to lack confidence in the results from BEMPs and building simulation methods. This paper compared the building thermal load modeling capabilities and simulation results of three BEMPs: EnergyPlus, DeST and DOE-2.1E. Test cases, based upon the ASHRAE Standard 140 tests, were designed to isolate and evaluate the key influencing factors responsible for the discrepancies in results between EnergyPlus and DeST. This included the load algorithms and some of the default input parameters. It was concluded that there is little difference between the results from EnergyPlus and DeST if the input values are the same or equivalent despite there being many discrepancies between the heat balance algorithms. DOE-2.1E can produce large errors for cases when adjacent zones have very different conditions, or if a zone is conditioned part-time while adjacent zones are unconditioned. This was due to the lack of a strict zonal heat balance routine in DOE-2.1E, and the steady state handling of heat flow through interior walls and partitions. This comparison study did not produce another test suite, but rather a methodology to design tests that can be used to identify and isolate key influencing factors that drive the building thermal loads, and a process with which to carry them out.

Keywords

building energy modeling program,
building thermal loads,
comparison,
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EnergyPlus

Article History

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1 Introduction

Computer simulation is an important and proven method to help understand and analyze the thermal performance of buildings, and predict their operational energy consumption. Since the 1960s, many building energy modeling programs (BEMPs) have been developed to perform building energy simulation, for instance, the widely-used DOE-2 (DOE-2 1980), EnergyPlus (Crawley et al. 2001), ESP (ESRU 1999), and DeST (Yan et al. 2008; Zhang et al. 2008). DOE-2 was developed at the Lawrence Berkeley National Laboratory with funding from the U.S. Department of Energy (USDOE) after the energy crisis in the late 1970s and is still the most widely-used BEMP in the U.S. This includes its use as a stand-alone calculation engine and with graphical user interfaces (GUI) such as VisualDOE (VisualDOE 2004), EnergyPro (EnergyPro 2011), eQuest (eQuest 2009), and EnergyGauge (EnergyGauge 2012). EnergyPlus is a next generation BEMP developed, supported and maintained by a team led and funded by USDOE since 1996. EnergyPlus is based on the load algorithms of BLAST and the system algorithms of DOE-2. New features and enhancements were added to support innovative, low-energy building designs and operational controls. Development of ESP-r started in 1974 at the University of Strathclyde and is primarily used in Europe. DeST (Designer's Simulation Toolkits) is a BEMP developed at Tsinghua University since the late 1980s with the aim of aiding teaching, research and the practical use of building energy analysis and simulation in China.

BEMPs play a significant role in the design of energy

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